embodiments the square waves representing Vstim can be preceded and followed by other non-DC signaling. If Vstim is applied to a row and a signal capacitance is present at a column connected to analog channel **300**, the output of charge amplifier **302** can be pulse train **310** centered at Vref with a peak-to-peak (p-p) amplitude in the steady-state condition that is a fraction of the p-p amplitude of Vstim, the fraction corresponding to the gain of charge amplifier **302**. For example, if Vstim includes **18**V p-p pulses and the gain of the charge amplifier is 0.1, then the output of the charge amplifier can be 1.8V p-p pulses. This output can be mixed in signal mixer **304** with demodulation waveform Vdem **316**.

[0038] Because Vstim can create undesirable harmonics, especially if formed from square waves, demodulation waveform Vdem **316** can be a Gaussian sine wave in an otherwise DC signal that is digitally generated from look-up table (LUT) **312** or other digital logic and synchronized to Vstim. In some embodiments, Vdem **316** can be tunable in frequency and amplitude by selecting different digital waveforms in LUT **312** or generating the waveforms differently using other digital logic. Signal mixer **304** can demodulate the output of charge amplifier **310** by subtracting Vdem **316** from the output to provide better noise rejection. Signal mixer **304** can reject all frequencies outside the passband, which can in one example be about ±15 kHz around Vdem. This noise rejection can be beneficial in noisy environment with many sources of noise, such as 802.11, Bluetooth and the like, all having some characteristic frequency that can interfere with the sensitive (femtofarad level) analog channel **300**. Signal mixer **304** is essentially a synchronous rectifier as the frequency of the signal at its inputs is the same, and as a result, signal mixer output **314** is essentially a rectified Gaussian sine wave.

[0039] Offset compensation **306** can then be applied to signal mixer output **314**, which can remove the effect of the static Csig, leaving only the effect of ΔCsig appearing as result **324**. Offset compensation **306** can be implemented using offset mixer **330**. Offset compensation output **322** can be generated by rectifying Vdem **316** using rectifier **332**, and mixing rectifier output **336** with analog voltage from a digital-to-analog converter (DAC) **320** in offset mixer **330**. DAC **320** can generate the analog voltage based on a digital value selected to increase the dynamic range of analog channel **300**. Offset compensation output **322**, which can be proportional to the analog voltage from DAC **320**, can then be subtracted from signal mixer output **314** using subtractor **334**, producing subtractor output **338** which can be representative of the change in the capacitance ΔCsig that occurs when a capacitive sensor on the row being stimulated has been touched. Subtractor output **338** is then integrated and can then be converted to a digital value by ADC **308**. In some embodiments, integrator and ADC functions are combined and ADC **308** may be an integrating ADC, such as a sigma-delta ADC, which can sum a number of consecutive digital values and average them to generate result **324**.

[0040] FIG. **3***b* is a more detailed view of charge amplifier (a virtual ground amplifier) **302** at the input of an analog channel, and the capacitance that can be contributed by the multi-touch panel (see dashed lines) and seen by the charge amplifier. As mentioned above, there can be an inherent stray capacitance Cstray at each pixel on the multi-touch panel. In virtual ground amplifier **302**, with the + (noninverting) input tied to Vref, the – (inverting) input is also driven to Vref, and a DC operating point is established. Therefore, regardless of how much Csig is present, the – input is always driven to Vref. Because of the characteristics of virtual ground amplifier **302**, any charge Qstray that is stored in Cstray is constant, because the voltage across Cstray is kept constant by the charge amplifier. Therefore, no matter how much stray capacitance Cstray is added to the – input, the net charge into Cstray will always be zero. Therefore the input charge Qsig_sense=(Csig–ΔCsig_sense)Vstim is zero when the corresponding row is kept at DC and is purely a function of Csig and Vstim when the corresponding row is stimulated. In either case, because there is not net charge into Cstray, the stray capacitance is rejected and essentially drops out of any equations. Thus, even with a hand over the multi-touch panel, although Cstray can increase, the output will be unaffected by the change in Cstray.

[0041] The gain of virtual ground amplifier **302** is usually small (e.g. 0.1) and is equivalent to the ratio of Csig (e.g. 2 pF) and feedback capacitor Cfb (e.g. 20 pF). The adjustable feedback capacitor Cfb converts the charge Qsig to the voltage Vout. Therefore, the output Vout of virtual ground amplifier **302** is a voltage that is equivalent to the ratio of –Csig/Cfb multiplied by Vstim referenced to Vref. The high voltage Vstim pulses can therefore appear at the output of virtual ground amplifier **302** as much smaller pulses having an amplitude identified by reference character **326**. However, when a finger is present, the amplitude of the output can be reduced as identified by reference character **328**, because the signal capacitance is reduced by ΔCsig.

[0042] FIG. **3***c* illustrates an exemplary Vstim signal with multiple pulse trains each having a fixed number of pulses, each pulse train having a different frequency (e.g. 140 kHz, 200 kHz, and 260 kHz). With multiple pulse trains at different frequencies, one or more results can be obtained at each frequency. If a static interferer is present at a particular frequency, the results at that frequency can be corrupted as compared to the results obtained at the other two frequencies, and those results can be eliminated. The results at the remaining two frequencies can be averaged to compute the result.

[0043] The multiple frequencies may be applied in different ways to the multi-touch panel. In some embodiments, N columns can be connected to one analog channel via N:1 demultiplexer. A given row would then have to be stimulated N times to acquire Csig for all columns and then repeated for the other two frequencies. This has the advantage that fewer channels are needed but it takes longer to process an image. In other embodiments, one channel can be allotted for each column. A given row only has to be stimulated once to acquire Csig for all columns and then repeated for the other two frequencies. This arrangement has the advantage that it is faster then the previous arrangement described earlier; however, it takes more dedicated channels, which may be necessary for large multi-touch panels and when communications are USB, which could drop packets if too slow. After an entire "image" is captured, it can be processed. In further embodiments, multiple stimuli (scan circuits) can be applied to different rows at the same time to speed up the process. The feedback capacitance Cfb and offset can also be programmable.

[0044] Embodiments of this invention relate to the use of one or more proximity sensors in combination with one or more touch sensors in a multi-touch panel to detect the presence of a finger, body part or other object and control or trigger one or more functions in accordance with an "image" of touch provided by the sensor outputs. In some embodiments, one or more infrared (IR) proximity sensors or other